(12) UK Patent Application (19) GB (11) 2 179 678 (13) A

(43) Application published 11 Mar 1987

(21) Application No 8620132

(22) Date of filing 19 Aug 1986

(30) Priority data

(31) 8521406 (32) 28 Aug 1985 (33) GB

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(51) INT CL[4]
C23C 14/06 14/34

(52) Domestic classification (Edition I)
C7F 1V2 2M 2Z11AX 2Z11AY 2Z5 4K 6D2 6F1
U1S 1647 1688 2003 C7F

(56) Documents cited
GB A 2090291 EP A2 0074322
EP A2 0089818 US 4486285
Note: US 4486285 and EP A2 0074322 are equivalent;
Welding Institute Reprint, Advances in Surface Coating Technology-International Conference, London, 13-15 February 1978, page 53-59,

(58) Field of search
C7F
Selected US specifications from IPC sub-class C23C

(54) Sputter ion plating of tungsten and carbon

(57) W and C are co-sputtered from a cathode comprising tungsten and carbon onto a substrate (e.g. a steel) by means of sputter ion plating to give a coating possessing erosion and wear resistant properties. The coating is believed to comprise a mixture of W_2C to provide hardness and W to provide ductility. The substrate may be an artefact such as a drill tip, hacksaw blade or slurry pump component.

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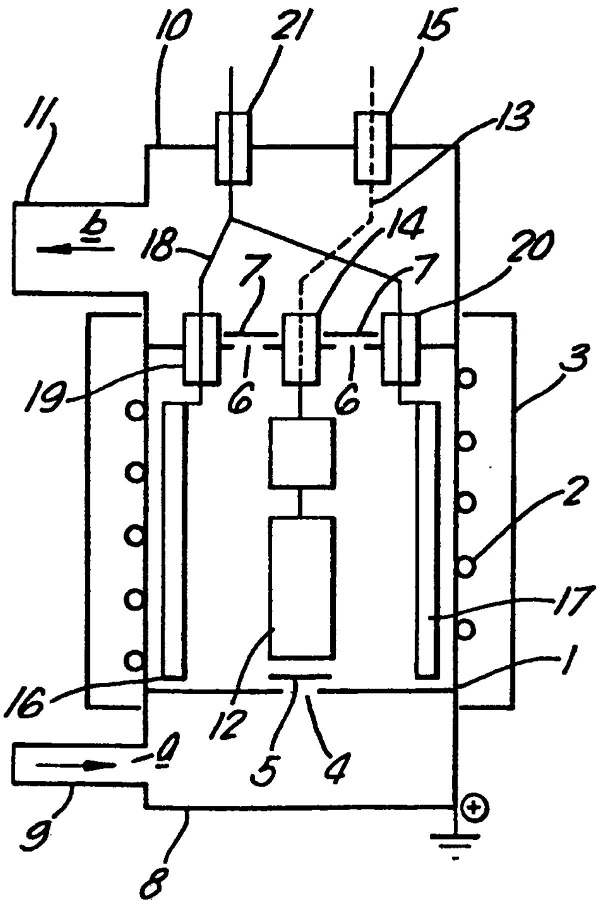
Fig .1.



SPECIFICATION

Coatings

This invention relatest the provisi n of coatings on substrates by sputter ion plating.

Sputter ion plating is a known coating technique for producing coatings of uniform thickness, high integrity and good bond strength. It basically comprises the transfer of material from a cathode to a substrate in the presence of a DC glow discharge in a soft vacuum chamber, the material being generated from the cathode by the action of ion bombardment, i.e. sputtering, and ultimately diffusing to the substrate to form a coating thereon. If desired, sputter ion plating may be carried out in a reactive environment so that the material generated from the cathode reacts with a reactive constituent thereof to form a coating that is chemically different from the cathode material. The latter procedure is known as 'reactive sputtering'. Sputter ion plating is described in detail in a number of references in the art, for example in "Wire Industry", *44*. December 1977, pages 771 to 777; Welding Institute Reprint, Advances in Surface Coating Technology - International Conference, London 13 - 15 February 1978, pages 53 - 59; and Proceedings of 'IPAT' Conference, Edinburgh (June 1977) ps. 177-186.

Examples of coating materials that have been applied by sputter ion plating are aluminium, copper, nickel, titanium, niobium, molybdenum, stainless steel, aluminium bearing ferritic steel, CoCrAlY, titanium carbide, chromium carbide, tungsten carbide and a mixed Ti/Ta carbide. In addition, aluminium oxide, titanium dioxide, aluminium nitride and titanium nitride have been applied by reactive sputtering of the appropriate metal in the presence of oxygen of nitrogen as reactive constituent as appropriate. Tungsten carbide can be applied by co-sputtering tungsten and graphite, or by reactive sputtering of tungsten, e.g. in a hydrocarbon atmosphere.

The invention is concerned with co-sputtering tungsten and carbon onto a substrate thereby to produce an erosion and wear resistant coating. Thus, the invention provides a method of forming a coating on a substrate by sputter ion plating by generating a DC glow discharge under soft vacuum conditions in the presence of the substrate and of a cathode comprising tungsten and carbon thereby to release material at the cathode by ion bombardment, which released material diffuses to the substrate to form the coating thereon, the conditions being such that the coating comprises a mixture of W_2C and W.

The W_2C, which is not necessarily stoichiometric, provides hardness in the coating and the W provides ductility. Coatings with useful properties may be achieved over a wide range of W_2C : W compositions. The coatings may additionally include WC.

Preferably, the co-sputtering of the tungsten and the carbon is carried ut using elemental W and C, the latter, for xample, being in the form of graphite.

The substrate may be a metallic substrate such as a steel (e.g. chr m ste l), and may be an artefact required to hav been er sion and wear resistant pr perties such as a drill tip, a blade for a hacksaw or a comp nent f r a pump (e.g. a slurry pump).

If desired, the substrate may be pr vided with a layer for improving the adhesion of the coating thereto. Such a layer may, for example, b in the form of a thin layer of nickel (e.g. of thickness 1-2 μm) produced, for example by sputter ion plating.

The invention will now be particularly described by way of example only with reference to the accompanying drawing the sole figure of which is a schematic diagram of an apparatus for carrying out sputter ion plating.

Referring to the figure, an earthed cylindrical coating chamber 1 is provided with an externally mounted resistance heater 2 having a cooling jacket 3. The coating chamber 1 has a gas inlet vent 4 with an associated baffle 5 and gas outlet vents 6 with associated baffles 7. The inlet vent 4 communicates with a getter chamber 8 provided with an inlet conduit 9 and the outlet vents 6 communicate with a pumping chamber 10 provided with a pumping port 11.

A substrate 12 is mounted in the coating chamber 1 and is electrically connected to a bias potential power supply (not shown) by a conductor 13 mounted in insulators 14 and 15 positioned in the walls of the pumping chamber 10. A cathode in the form of a series of target plates of which two 16 and 17 are shown is also mounted within the coating chamber 1. The cathode (e.g. 16 and 17) is electrically connected to a cathode power supply (not shown) by a conductor 18 mounted in insulators 19, 20 and 21 positioned in the walls of the pumping chamber 10.

In operation of the apparatus shown in the figure, an operating gas is supplied at the inlet conduit 9 and, by operation of a pump (not shown) at the pumping port 11, is drawn into the getter chamber 8 as shown by arrow *a* and thence into the coating chamber 1 via inlet vent 4. The coating chamber 1 is heated by means of the heater 2 in order to outgas the substrate 12, cathode (e.g. 16 & 17) and evaporate any organic material. Undesired gas and vapour leave the coating chamber 1 via the outlet vents 6 to enter the pumping chamber 10 and are removed via the pumping port 11 as shown by arrow *b*. A high negative voltage is applied to the target plates (e.g. 16 and 17) by means of the cathode power supply (not shown) to produce a glow discharge with net transfer of cathode material therefrom by sputtering onto the substrate 12 to provide a coating thereon. External heating is not required at this stage since the process generates sufficient power to maintain the operating temperature. If desired, a negative bias may be applied to the substrate 12 during coating by means of the bias potential power supply (not shown). This is to densify the coating by resputtering of deposited material and ion polishing.

EXAMPLE

General procedure

The apparatus shown in the figure was us d and the coating chamber 1 pumped down to 10-100 m torr pressure with a flowing high purity arg n atmosphere purified by passing over freshly dep sit d titanium. The coating chamb r 1 was h ated to a temperatur of around 300°C to effect outgassing of

the substrate 12 and the cathode e.g. 16 and 17 and evaporati n of any organic mat rial. A high negative voltage (400 V to 1000 V) was then applied t the cathode e.g. 16 and 17 to produce a glow discharge with net transfer of material therefrom to the substrate 12 to effect coating thereof. If desired, a negative bias of 20 to 150 V was applied to the coated substrate 12 to densify the coating.

The general procedure described above was used to coat a chrome steel substrate with a coating comprising W_2C and W, by using a cathode comprising elemental W and graphite.

CLAIMS

1. A method of forming a coating on a substrate by sputter ion plating by generating a DC glow discharge under soft vacuum conditions in the presence of the substrate and of a cathode comprising tungsten and carbon thereby to release material at the cathode by ion bombardment, which released material diffuses to the substrate to form the coating thereon, the conditions being such that the coating comprises a mixture of W_2C and W.

2. A method according to claim 1 wherein the tungsten and the carbon are each in elemental form in the cathode.

3. A method according to claim 2 wherein the carbon is in the form of graphite.

4. A method according to any of the preceding claims wherein the substrate is a steel substrate.

5. A method of forming a coating on a substrate substantially as described herein with reference to the example.

6. A coated substrate made by a method according to any of the preceding claim.

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Published by The Patent Office, 25 Southampton Buildings, London WC2A 1AY, from which copies may be obtained.